

**NASA
Technical
Memorandum**

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**SPACE STATION *FREEDOM* DELTA PRESSURE LEAKAGE
RATE COMPARISON TEST DATA ANALYSIS REPORT**

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DELTA PRESSURE LEAKAGE RATE COMPARISON TEST
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TABLE OF CONTENTS

	Page
1.0 INTRODUCTION	1
2.0 CONCLUSIONS	1
3.0 RECOMMENDATIONS	1
4.0 DISCUSSION	2
4.1 Test Configuration	2
4.2 Approach	3
4.3 Results	5
APPENDIX A—Test Data Listing	9
APPENDIX B—Flow Ratio Plots	19
REFERENCE	23

LIST OF ILLUSTRATIONS

Figure	Title	Page
1.	General test arrangement	2
2.	Fixture groove dimensions	2
3.	System mass versus time plot	4
4.	Pressure range example plot	4
5.	Flow ratio versus flow plot	6
6.	Orifice cap configuration	6

TECHNICAL MEMORANDUM

SPACE STATION *FREEDOM* DELTA PRESSURE LEAKAGE RATE COMPARISON TEST DATA ANALYSIS REPORT

1.0 INTRODUCTION

Seal verification for Space Station *Freedom* (S.S. *Freedom*) is required to prove the ability of each seal to perform as designed prior to launch. In order to test the seal, gas leakage across the seal must be determined with a pressure differential of one atmosphere. Two methods of testing present the most logical way of verifying S.S. *Freedom* seals. One method would test the seal under conditions similar to those experienced during normal operation (i.e., one atmosphere internal—vacuum external). The other method would create the necessary pressure differential across the seal, but would not require the vacuum environment on the exterior side of the seal (i.e., two atmospheres internal—one external). For simplicity, these tests are referred to as 1/0 and 2/1. Two questions need to be answered:

What is the relationship between the two leakage rates?

Does the relationship always hold true?

2.0 CONCLUSIONS

Results of the testing performed agreed very closely with theoretical analyses relating leakage rates at different pressure ratios. The leakage rates experienced during 2/1 testing were always higher than the counterpart test performed under 1/0 conditions. Typical ratios of 2/1-to-1/0 leakage rates were near 3. When tested under 2/1 conditions, seal behavior under 1/0 conditions could be estimated with small uncertainties. When gas permeation was the major contributor to leakage, or the flaw created a long tortuous path, actual flow ratios agreed with the calculations. As the flaw configuration changed to that of an abrupt exit (orifice plate), ratios between 2/1 and 1/0 became even more conservative. The orifice type leak created a 2/1-to-1/0 ratio of 6.

3.0 RECOMMENDATIONS

Testing performed indicates that verifying the seals under 2/1 conditions is always conservative. Test 1/0 leakage rates can be extrapolated from 2/1 conditions quite accurately; however, this is not recommended. The reduced leakage that would occur once in orbit should be taken as an increased margin of safety, and to provide for some long-term seal degradation. Since leakage rates are conservative under the 2/1 pressure conditions, and testing a complete module in a vacuum chamber would be costly and might introduce scheduling conflicts, it is recommended that S.S. *Freedom* modules be tested using the 2/1 approach when possible.

4.0 DISCUSSION

4.1 Test Configuration

The test setup consisted of a regulated gaseous nitrogen source, connecting lines, isolation valve, pressure transducers, temperature sensors, O-ring fixture, and bell jar/vacuum pump as shown in figure 1.

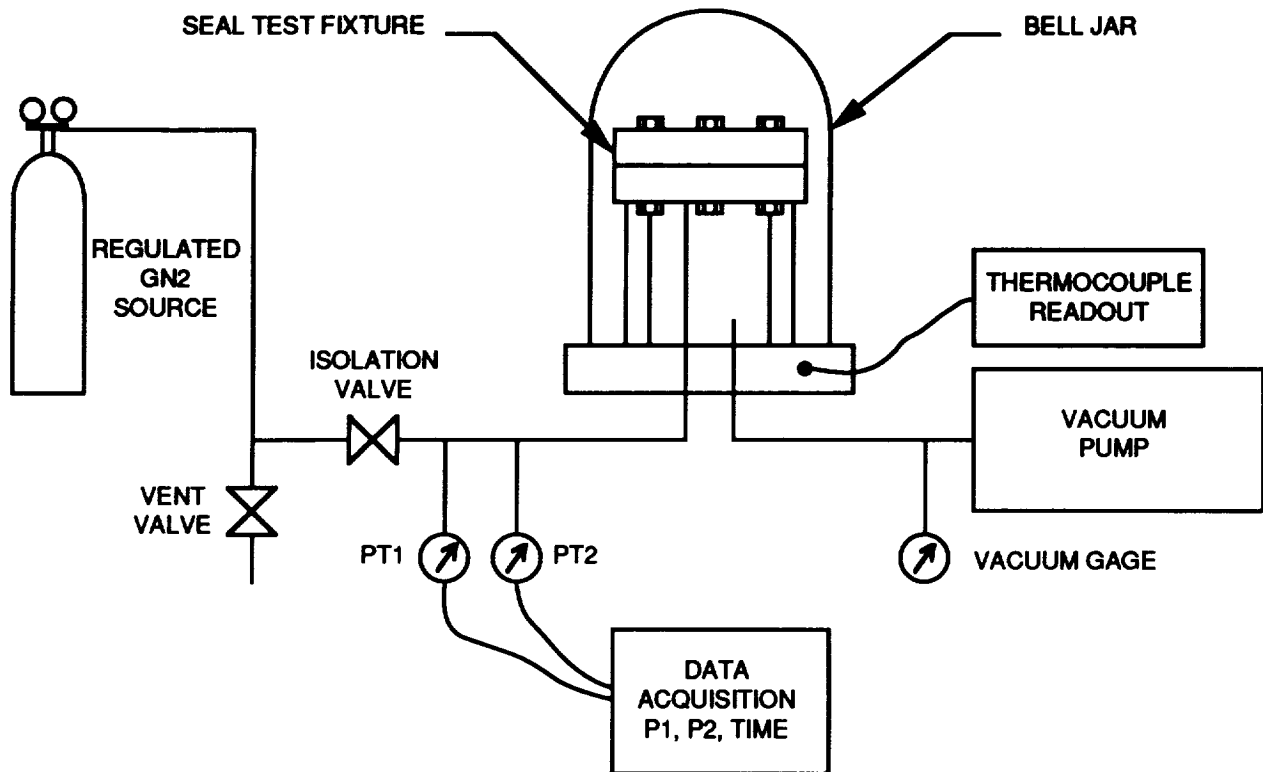


Figure 1. General test arrangement.

The fluorocarbon (V747 Viton) O-rings used had a 5.19-in outside diameter and a 0.281-in cross-sectional diameter. Groove dimensions for the fixture are shown in figure 2. Shims placed between the plates of the test fixture created a 17-percent squeeze on the O-ring. No lubrication was used on the O-rings to help eliminate a very "hard-to-control" variable. When tested under vacuum conditions, the bell jar was pumped below 1-torr absolute pressure. Pressure data was collected with a desktop computer. Temperature was manually recorded in the data file for each test. The flaws were created by laying a wire or fiber radially across the sealing surface of the O-ring.

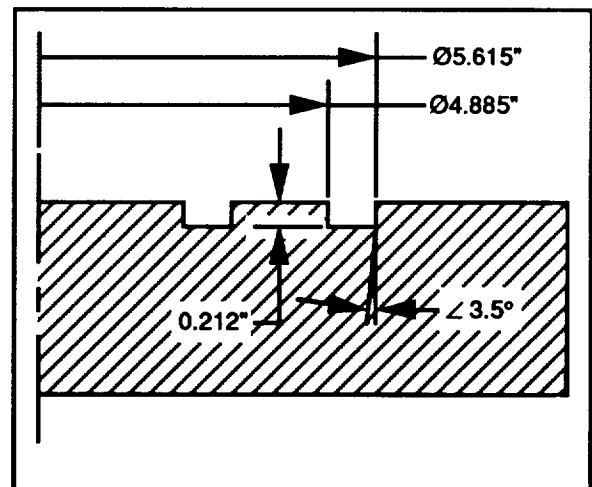


Figure 2. Fixture groove dimensions.

4.2 Approach

Leakage rates were calculated using the mass point analysis approach, calculating the mass of nitrogen in the fixture using the ideal gas law:

$$M_i = \frac{P_i \cdot V}{R \cdot T_i} .$$

Conversion from units mass measurement to standard volume units is accomplished by multiplying the mass by the specific volume at standard conditions of 14.696 psia and 60 °F:

$$Q_i = M_i \cdot v \quad v = \frac{R \cdot T_{std}}{P_{std}} ,$$

∴

$$Q_i = \frac{P_i \cdot V}{R \cdot T_i} \cdot \frac{R \cdot T_{std}}{P_{std}} = \frac{P_i \cdot V \cdot T_{std}}{T_i \cdot P_{std}} . \quad (1)$$

In equation (1), Q_i is the volume of gas in standard cubic centimeters, P_i and T_i are the system pressure and temperature at time t_i in psia (or kPa) and °R (or K), respectively. V is the system volume in cubic centimeters, T_{std} is the standard temperature in °R (or K), and P_{std} is the standard pressure in psia (or kPa).

Leakage rates are then calculated using a least squares fit of Q_i versus time, with time in seconds. The resulting slope from the fit is the leakage rate in standard cubic centimeters per second (sccs). The y intercept is the initial mass of the system in standard cubic centimeters (scc). A typical plot of this data is shown in figure 3.

The data used to calculate the leakage rate was chosen using barometric pressure during that test series as the ideal one atmosphere. For example, if P_{atm} was 14.5 psia, 29.0 would be used for a 2/1 test. Pressure in the fixture would start out higher than 29.0 and decay through that number. The slope of the line was calculated with the ideal pressure in the center of the data, and a small range above and below the ideal as shown in figure 4.

Every flaw was tested three times at each pressure level with the results averaged to obtain the final leakage for that test condition.

Poiseuille's law for viscous flow through a cylindrical tube¹ defines the relationship between leakage and pressure as:

$$Q = \frac{\pi \cdot d^4}{256 \cdot l \cdot \mu} \cdot (P_e^2 - P_i^2) . \quad (2)$$

In equation (2), Q is leakage, d and l are the average diameter and length, respectively, of the leak hole, and μ is the gas viscosity. P_e and P_i are the external and internal pressures, respectively.

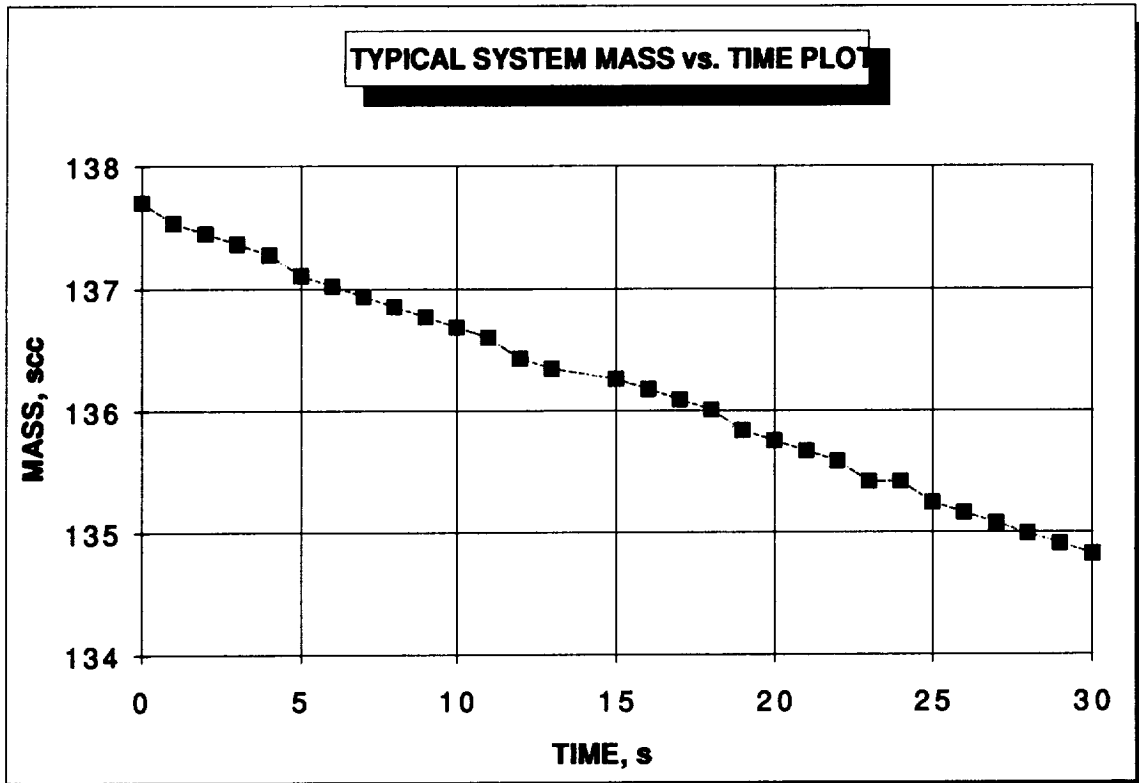


Figure 3. System mass versus time plot.

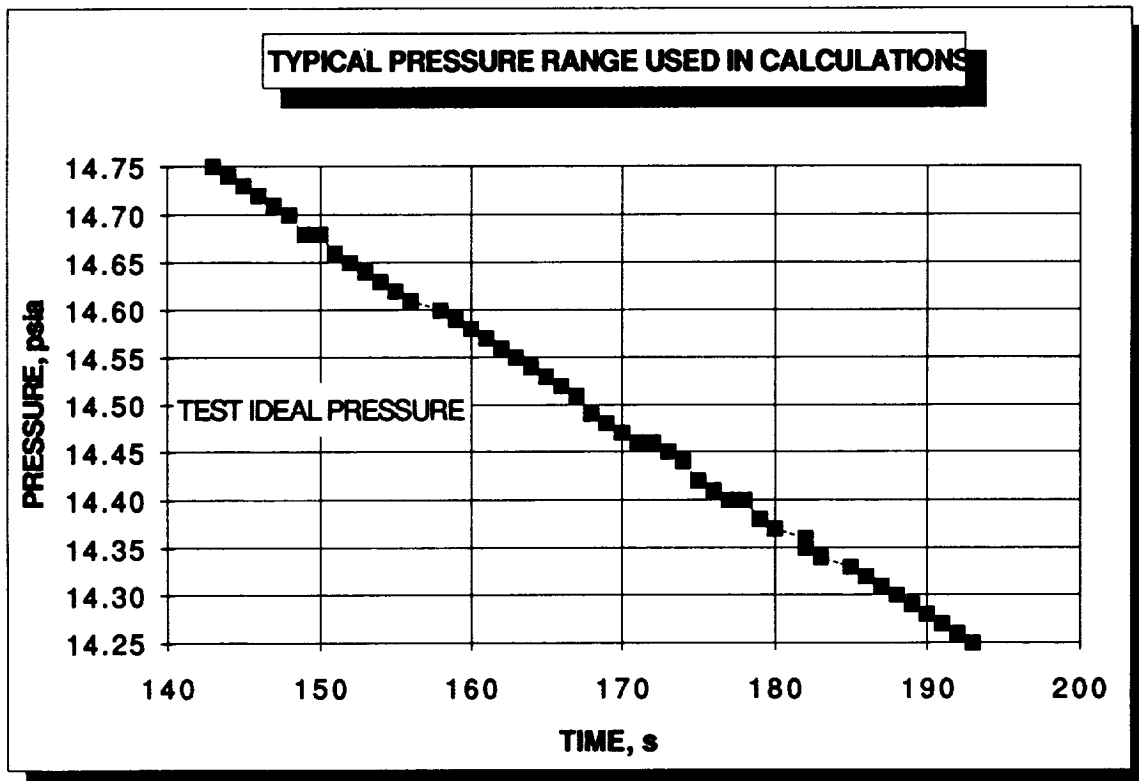


Figure 4. Pressure range example plot.

Assuming the small changes in absolute pressures acting on seal under the different test conditions do not affect the geometry of the leak path, equation (2) can be simplified as:

$$Q = C \cdot (P_e^2 - P_i^2) , \quad (3)$$

where C is constant for a certain flaw and various pressure ratios under consideration. Relating leakage rates at different pressure ratios becomes an exercise in mathematic ratios:

$$\frac{Q_{a/b}}{Q_{c/d}} = \frac{(P_a^2 - P_b^2)}{(P_c^2 - P_d^2)} , \quad (4)$$

∴

$$\frac{Q_{2/1}}{Q_{1/0}} = \frac{(P_2^2 - P_1^2)}{(P_1^2 - P_0^2)} \quad \text{or} \quad Q_{2/1} = \frac{(P_2^2 - P_1^2)}{(P_1^2 - P_0^2)} \cdot Q_{1/0} ,$$

$$Q_{2/1} = \frac{(2^2 - 1^2)}{(1^2 - 0^2)} \cdot Q_{1/0} = \frac{3}{1} \cdot Q_{1/0} .$$

4.3 Results

Complete results of each test are included as appendix A. Average results from each series are shown on page 10. Each test is identified by a series of alphanumeric digits that define the test pressures, flaw size included, configuration number, and run number. A typical test identification example would be:

$$2/1 - 004 - 1 - 2$$

where

2/1 = pressure ratio across seal

004 = flaw size (wire diameter in thousandths of an inch)

1 = configuration number (1–first seal, 2–second, ...)

2 = test run number for particular configuration (1, 2, or 3).

The baseline (no flaw) and 0.0018-in flaw tests were repeated after initial data analysis because of erroneously high ratios (some at 8 to 1). The test fixture was set up using flex lines connecting the pressure transducers to the remainder of the system. It appeared permeation through the lines was causing as much or more leakage as the leakage through the seal when subjected to pressures above one atmosphere. When testing with one atmosphere internal pressure, the flex lines did not have any pressure differential across them, which eliminated the tendency for the gas to permeate. The flex lines were replaced by hard tubing and the test results were much better. Figure 5 shows the data plotted with flow ratio versus flaw. The flaws are arranged in order of increasing leakage rate. The remaining five ratios that can be calculated from the data are plotted and included in appendix B.

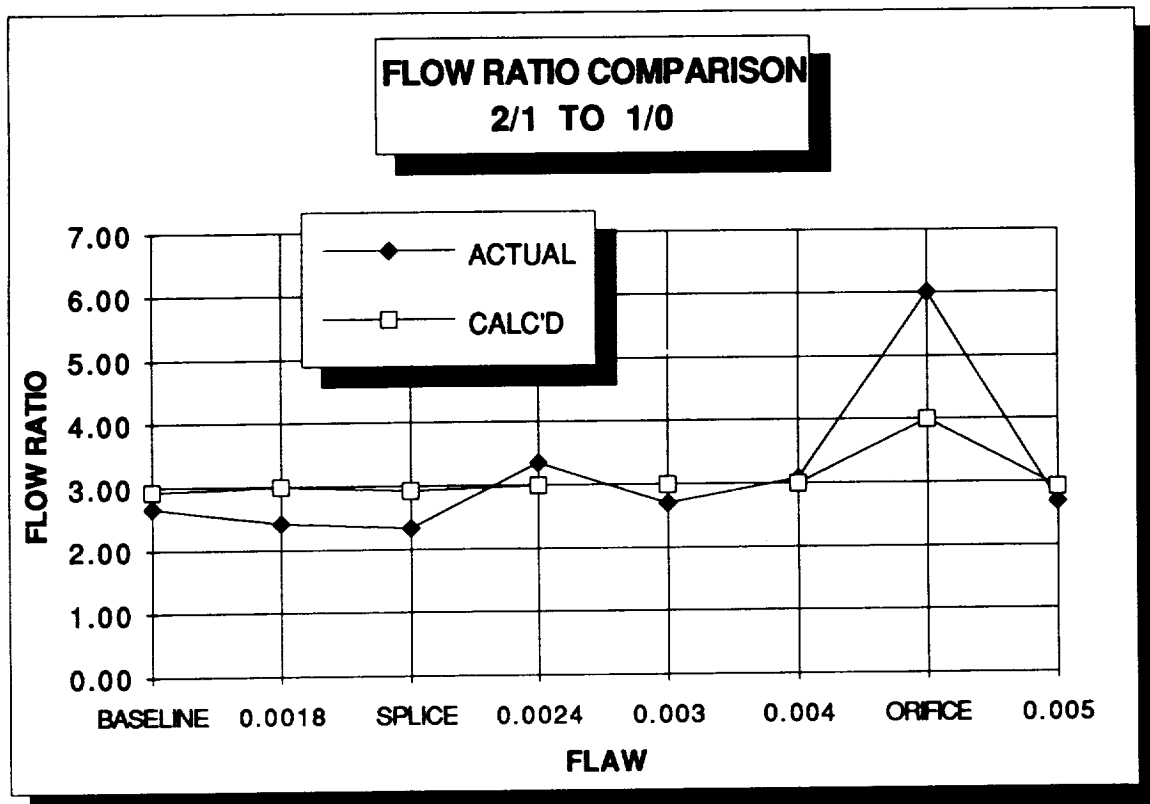


Figure 5. Flow ratio versus flaw plot.

The test series labeled "SPLICE" on the graph was an added bonus in the matrix. During the first test attempt, it was noticed immediately that the leak rate was much too high for a baseline configuration. The fixture was disassembled and examined. The O-ring used has a poor splice that left a "necked down" section with a radially directed valley that created a leak path. A different O-ring with a good splice was used for all other test series.

The test series which incorporated an orifice was included after the tubing configuration change. The orifice was created by drilling a 0.001-in hole in the end of a flare fitting cap as shown in figure 6. The cap was connected to a spare bulkhead fitting in the pneumatic circuit. The "good" seal (no flaw) was used in this series.

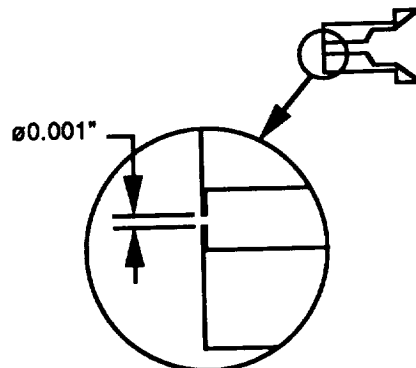


Figure 6. Orifice cap configuration.

Results from these tests did not correspond as well as other series in the matrix, even though 2/1 rates were higher. It appears the flow had become “choked” in nature because of the configuration. The flow through the orifice could not increase once exit pressures were below the critical value given by:

$$P_{cr} = P_r \cdot \{2/(k+1)\}^{\{k/(k-1)\}} , \quad (5)$$

which, for gaseous nitrogen equals 0.53. During 1/0 tests, for a fixture pressure of 14.5 psia, flow could not increase after the external pressure dropped below 7.7 psia. Still the flow ratio calculated using this method to determine the exit pressure does not match the actual flow ratios measured. Equation (4) was developed based on laminar flow. Critical flow through the orifice does not follow this behavior, resulting in the discrepancy.

APPENDIX A
Test Data Listing

DELTA PRESSURE LEAK RATE COMPARISON TEST RESULTS

FLOW DATA

	PRESSURE RATIO			
	'2/1'	'1.5/1'	'1.5/0'	'1/0'
FLAW				
0.0050	5.82E-1	3.10E-1	3.89E-1	2.16E-1
ORIFICE	5.07E-1	2.57E-1	1.26E-1	8.43E-2
0.0040	2.06E-1	9.10E-2	1.37E-1	6.70E-2
0.0030	1.75E-1	7.99E-2	1.33E-1	6.45E-2
0.0024	4.43E-2	1.57E-2	2.87E-2	1.32E-2
SPLICE	4.21E-3	1.78E-3	3.72E-3	1.79E-3
0.0018	4.19E-3	1.75E-3	3.50E-3	1.73E-3
BASLINE	1.65E-4	7.48E-5	1.06E-4	6.20E-5

	2/1-1/0 FLOW RATIO			2/1-1.5/0 FLOW RATIO			2/1-1.5/1 FLOW RATIO		
	ACTUAL	CALC'D	% DIFF.	ACTUAL	CALC'D	% DIFF.	ACTUAL	CALC'D	% DIFF.
FLAW									
0.0050	2.70	2.93	9	1.50	1.33	-11	1.88	2.39	27
ORIFICE	6.01	4.00	-33	4.02	1.78	-56	1.97	2.31	17
0.0040	3.08	3.00	-3	1.50	1.33	-11	2.27	2.40	6
0.0030	2.71	3.00	11	1.31	1.33	1	2.19	2.40	10
0.0024	3.35	3.00	-11	1.54	1.33	-14	2.82	2.40	-15
SPLICE	2.35	2.92	25	1.13	1.33	18	2.36	2.45	4
0.0018	2.42	3.00	24	1.20	1.33	11	2.39	2.40	0
BASLINE	2.67	2.93	10	1.56	1.29	-17	2.21	2.36	7

	1.5/1-1/0 FLOW RATIO			1.5/1-1.5/0 FLOW RATIO		
	ACTUAL	CALC'D	% DIFF.	ACTUAL	CALC'D	% DIFF.
FLAW						
0.0050	1.44	1.25	-13	0.80	0.56	-30
ORIFICE	3.05	1.73	-43	2.04	0.77	-62
0.0040	1.36	1.25	-8	0.66	0.56	-16
0.0030	1.24	1.25	1	0.60	0.56	-8
0.0024	1.19	1.25	5	0.55	0.56	2
SPLICE	0.99	1.22	22	0.48	0.56	16
0.0018	1.01	1.25	23	0.50	0.56	11
BASLINE	1.21	1.25	4	0.71	0.56	-22

	1.5/0-1/0 FLOW RATIO		
	ACTUAL	CALC'D	% DIFF.
FLAW			
0.0050	1.80	2.25	25
ORIFICE	1.49	2.25	51
0.0040	2.05	2.25	10
0.0030	2.06	2.25	9
0.0024	2.17	2.25	4
SPLICE	2.08	2.19	6
0.0018	2.02	2.25	11
BASLINE	1.70	2.25	32

000-3 Average Data

2/1-000-3	T96 Stats		T97 Stats		T98 Stats		2/1-000-3 Averages -0.00017 sccs 246.0 scc 0.9898
	P1 Stats	P2 Stats	P1 Stats	P2 Stats	P1 Stats	P2 Stats	
	SLOPE INTERCEPT R^2	-0.00012 249.1 0.9920	-0.00013 249.5 0.9808	-0.00017 244.2 0.9910	-0.00021 244.4 0.9888	-0.00020 244.6 0.9951	
1.5/1-000-3	T93 Stats		T94 Stats		T95 Stats		1.5/1-000-3 Averages -0.00007 sccs 184.7 scc 0.9656
	P1 Stats	P2 Stats	P1 Stats	P2 Stats	P1 Stats	P2 Stats	
	SLOPE INTERCEPT R^2	-0.00010 183.5 0.9434	-0.00011 185.2 0.9945	-0.00004 184.9 0.9243	-0.00005 185.3 0.9717	-0.00004 185.3 0.9906	
1.5/0-000-3	T120 Stats		T121 Stats		T122 Stats		1.5/0-000-3 Averages -0.00011 sccs 188.0 scc 0.9862
	P1 Stats	P2 Stats	P1 Stats	P2 Stats	P1 Stats	P2 Stats	
	SLOPE INTERCEPT R^2	-0.00017 187.7 0.9715	-0.00012 188.2 0.9797	-0.00009 187.8 0.9967	-0.00008 187.6 0.9833	-0.00008 188.4 0.9983	
1/0-000-3	T117 Stats		T118 Stats		T119 Stats		1/0-000-3 Averages -0.00006 sccs 124.9 scc 0.9632
	P1 Stats	P2 Stats	P1 Stats	P2 Stats	P1 Stats	P2 Stats	
	SLOPE INTERCEPT R^2	-0.00011 124.7 0.9757	-0.00004 124.9 0.9040	-0.00008 124.7 0.9690	-0.00005 124.7 0.9966	-0.00004 125.2 0.9661	

0018-3 Average Data

2/1-0018-3	T114 Stats	T115 Stats	T116 Stats	2/1-0018-3 Averages -0.00419 sccs 252.2 scc 0.9997
	P1 Stats -0.00418 251.9 0.9998	P1 Stats -0.00422 251.9 0.9999	P1 Stats -0.00418 251.7 0.9997	
	P2 Stats -0.00422 252.5 0.9993	P2 Stats -0.00418 252.5 0.9997	P2 Stats -0.00415 252.5 0.9996	
1.5/1-0018-3	T111 Stats	T112 Stats	T113 Stats	1.5/1-0018-3 Averages -0.00175 sccs 188.6 scc 0.9993
	P1 Stats -0.00175 188.2 0.9991	P1 Stats -0.00175 188.3 0.9994	P1 Stats -0.00177 188.3 0.9995	
	P2 Stats -0.00174 188.8 0.9992	P2 Stats -0.00174 188.9 0.9993	P2 Stats -0.00177 188.9 0.9995	
1.5/0-0018-3	T108 Stats	T109 Stats	T110 Stats	1.5/0-0018-3 Averages -0.00350 sccs 189.2 scc 0.9997
	P1 Stats -0.00354 188.9 0.9997	P1 Stats -0.00347 188.8 0.9998	P1 Stats -0.00348 188.8 0.9999	
	P2 Stats -0.00353 189.5 0.9995	P2 Stats -0.00346 189.4 0.9997	P2 Stats -0.00352 189.5 0.9998	
1/0-0018-3	T105 Stats	T106 Stats	T107 Stats	1/0-0018-3 Averages -0.00173 sccs 126.6 scc 0.9992
	P1 Stats -0.00175 126.5 0.9994	P1 Stats -0.00175 126.4 0.9996	P1 Stats -0.00172 127.3 0.9987	
	P2 Stats -0.00175 126.1 0.9995	P2 Stats -0.00175 126.0 0.9996	P2 Stats -0.00167 127.4 0.9986	

Poor Splice Average Data

2/1-SPLICE-3	T84 Stats	T85 Stats		T86 Stats		2/1-SPLICE-3 Averages -0.00421 sccs 245.8 scc 0.9995
	P1 Stats	P2 Stats	P1 Stats	P2 Stats	P1 Stats	
	SLOPE INTERCEPT R^2	-0.00416 246.1 0.9995	-0.00419 245.6 0.9993	-0.00420 245.9 0.9999	-0.00417 245.5 0.9997	
1.5/1-SPLICE-3	T81 Stats	T82 Stats		T83 Stats		1.5/1-SPLICE-3 Averages -0.00178 sccs 185.4 scc 0.9985
	P1 Stats	P2 Stats	P1 Stats	P2 Stats	P1 Stats	
	SLOPE INTERCEPT R^2	-0.00180 185.3 0.9981	-0.00179 185.1 0.9977	-0.00179 185.4 0.9995	-0.00177 185.2 0.9970	
1.5/0-SPLICE-3	T78 Stats	T79 Stats		T80 Stats		1.5/0-SPLICE-3 Averages -0.00372 sccs 185.4 scc 0.9997
	P1 Stats	P2 Stats	P1 Stats	P2 Stats	P1 Stats	
	SLOPE INTERCEPT R^2	-0.00364 185.2 0.9996	-0.00366 185.0 0.9994	-0.00369 185.5 0.9998	-0.00370 185.3 0.9998	
1/0-SPLICE-3	T75 Stats	T76 Stats		T77 Stats		1/0-SPLICE-3 Averages -0.00179 sccs 126.5 scc 0.9988
	P1 Stats	P2 Stats	P1 Stats	P2 Stats	P1 Stats	
	SLOPE INTERCEPT R^2	-0.00159 126.5 0.9991	-0.00153 126.5 0.9966	-0.00185 126.5 0.9998	-0.00182 126.4 0.9988	

2/1-0024-2	T51 Stats P1 Stats -0.04672 246.3 0.9992	P2 Stats -0.04623 246.1 0.9989	T52 Stats P1 Stats -0.04383 246.5 0.9995	P2 Stats -0.04345 246.2 0.9992	T53 Stats P1 Stats -0.04287 246.6 0.9997	P2 Stats -0.04250 246.3 0.9993	2/1-0024-2 Averages -0.04427 246.3 0.9993
1.5/1-0024-2	T60 Stats P1 Stats -0.01593 185.4 0.9997	P2 Stats -0.01550 185.3 0.9974	T61 Stats P1 Stats -0.01575 185.4 0.9998	P2 Stats -0.01572 185.3 0.9974	T62 Stats P1 Stats -0.01566 185.4 0.9993	P2 Stats -0.01552 185.3 0.9987	1.5/1-0024-2 Averages -0.01568 185.3 0.9987
1.5/0-0024-2	T57 Stats P1 Stats -0.02922 185.6 0.9995	P2 Stats -0.02845 185.5 0.9958	T58 Stats P1 Stats -0.02870 185.5 0.9992	P2 Stats -0.02838 185.5 0.9962	T59 Stats P1 Stats -0.02877 185.4 0.9998	P2 Stats -0.02847 185.4 0.9972	1.5/0-0024-2 Averages -0.02867 185.5 0.9980
1/0-0024-2	T54 Stats P1 Stats -0.01302 126.4 0.9998	P2 Stats -0.01322 127.1 0.9977	T55 Stats P1 Stats -0.01304 126.2 0.9998	P2 Stats -0.01329 126.7 0.9985	T56 Stats P1 Stats -0.01315 126.4 0.9997	P2 Stats -0.01349 126.8 0.9979	1/0-0024-2 Averages -0.01320 126.6 0.9989

003-2 Average Data

2/1-003-2	T36 Stats	T37 Stats		T38 Stats		2/1-003-2 Averages -0.17471 sccs 245.7 scc 0.9993
	P1 Stats	P2 Stats	P1 Stats	P2 Stats	P1 Stats	
	SLOPE INTERCEPT R^2	-0.17354 245.7 0.9992	-0.17274 245.5 0.9991	-0.17557 245.9 0.9993	-0.17614 245.9 0.9994	
1.5/1-003-2	T33 Stats	T34 Stats		T35 Stats		1.5/1-003-2 Averages -0.07994 sccs 185.2 scc 0.9984
	P1 Stats	P2 Stats	P1 Stats	P2 Stats	P1 Stats	
	SLOPE INTERCEPT R^2	-0.07984 185.2 0.9989	-0.08123 185.3 0.9986	-0.07987 185.2 0.9990	-0.07926 185.2 0.9983	
1.5/0-003-2	T30 Stats	T31 Stats		T32 Stats		1.5/0-003-2 Averages -0.13292 sccs 185.3 scc 0.9987
	P1 Stats	P2 Stats	P1 Stats	P2 Stats	P1 Stats	
	SLOPE INTERCEPT R^2	-0.13293 185.2 0.9992	-0.13370 185.2 0.9987	-0.13316 185.2 0.9991	-0.13207 185.3 0.9991	
1/0-003-2	T27 Stats	T28 Stats		T29 Stats		1/0-003-2 Averages -0.06445 sccs 130.1 scc 0.9982
	P1 Stats	P2 Stats	P1 Stats	P2 Stats	P1 Stats	
	SLOPE INTERCEPT R^2	-0.06515 130.0 0.9984	-0.06554 130.3 0.9978	-0.06438 130.0 0.9986	-0.06330 129.8 0.9980	

004-2 Average Data

2/1-004-2	T15 Stats		T16 Stats		T17 Stats		2/1-004-2 Averages -0.2063 sccs 246.0 scc 0.9987
	P1 Stats	P2 Stats	P1 Stats	P2 Stats	P1 Stats	P2 Stats	
	SLOPE INTERCEPT R^2	-0.2124 246.1 0.9985	-0.2113 246.0 0.9985	-0.2031 245.9 0.9987	-0.2036 246.0 0.9990	-0.2013 245.8 0.9987	
1.5/1-004-2	T18 Stats		T19 Stats		T20 Stats		1.5/1-004-2 Averages -0.0910 sccs 185.4 scc 0.9991
	P1 Stats	P2 Stats	P1 Stats	P2 Stats	P1 Stats	P2 Stats	
	SLOPE INTERCEPT R^2	-0.0910 185.4 0.9991	-0.0917 185.6 0.9992	-0.0915 185.5 0.9988	-0.0897 185.3 0.9992	-0.0909 185.5 0.9988	
1.5/0-004-2	T21 Stats		T22 Stats		T23 Stats		1.5/0-004-2 Averages -0.1374 sccs 185.6091 scc 0.9993
	P1 Stats	P2 Stats	P1 Stats	P2 Stats	P1 Stats	P2 Stats	
	SLOPE INTERCEPT R^2	-0.1371 185.5 0.9994	-0.1378 185.7 0.9994	-0.1383 185.7 0.9991	-0.1367 185.5 0.9995	-0.1372 185.7 0.9994	
1/0-004-2	T24 Stats		T25 Stats		T26 Stats		1/0-004-2 Averages -0.0670 sccs 130.3 scc 0.9988
	P1 Stats	P2 Stats	P1 Stats	P2 Stats	P1 Stats	P2 Stats	
	SLOPE INTERCEPT R^2	-0.0667 130.1 0.9987	-0.0672 130.6 0.9981	-0.0675 130.6 0.9989	-0.0667 130.1 0.9989	-0.0674 130.5 0.9988	

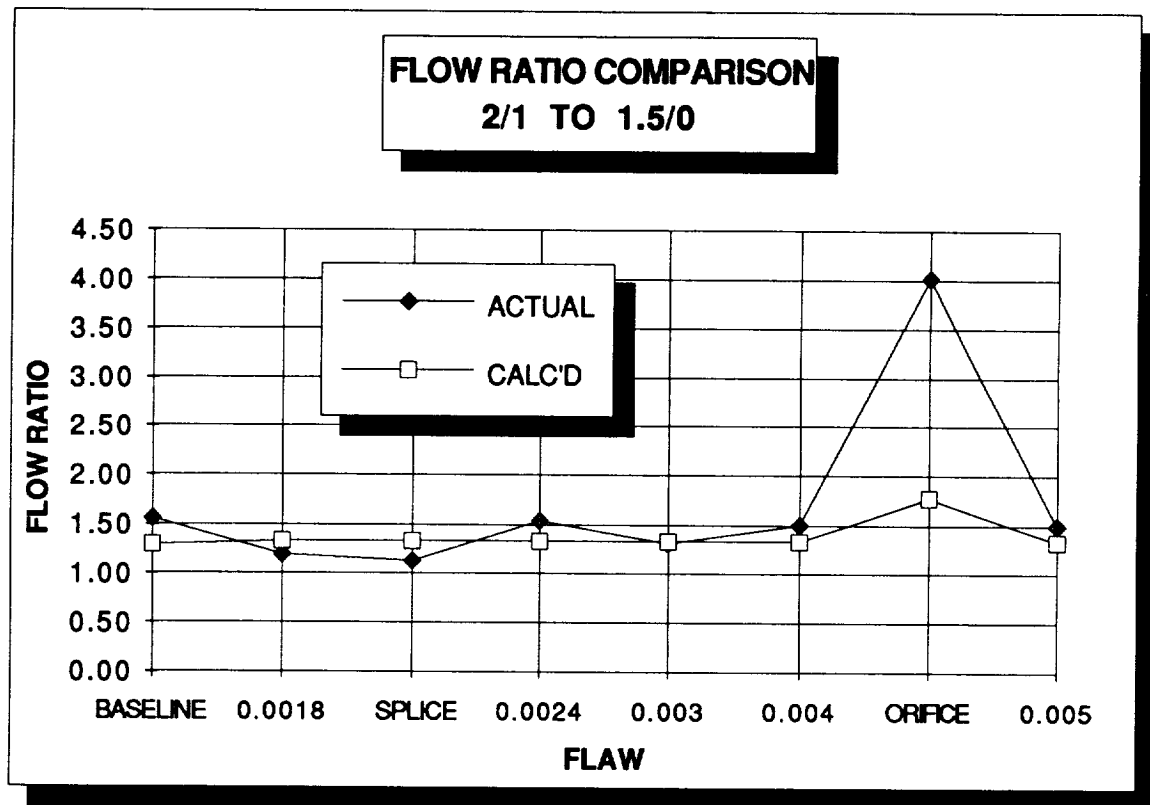
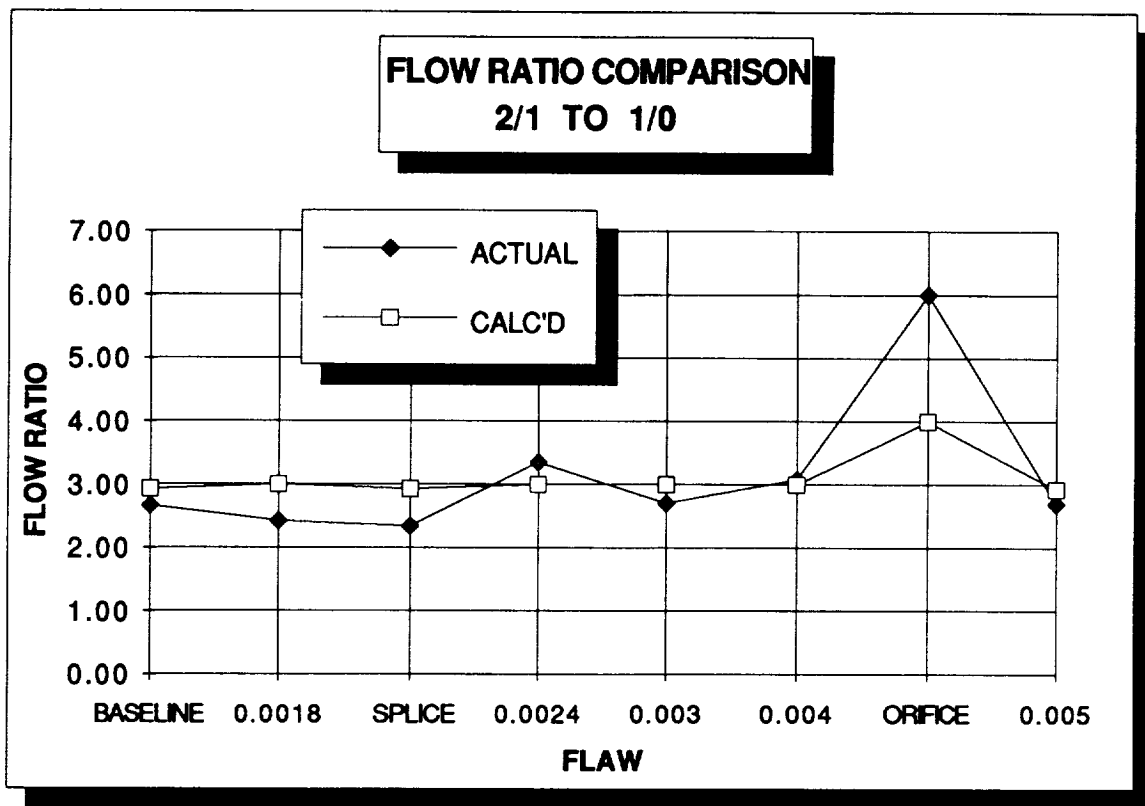
Orifice Cap Average Data

2/1-CAP-3	T90 Stats		T91 Stats		T92 Stats		2/1-CAP-3 Averages -0.5070 sccs 259.9 scc 0.9975
	P1 Stats	P2 Stats	P1 Stats	P2 Stats	P1 Stats	P2 Stats	
	SLOPE INTERCEPT R^2	-0.5049 260.0 0.9974	-0.5068 259.4 0.9974	-0.5086 259.7 0.9974	-0.5067 259.9 0.9977	-0.5079 260.2 0.9978	
1.5/1-CAP-3	T87 Stats		T88 Stats		T89 Stats		1.5/1-CAP-3 Averages -0.2575 sccs 199.8 scc 0.9926
	P1 Stats	P2 Stats	P1 Stats	P2 Stats	P1 Stats	P2 Stats	
	SLOPE INTERCEPT R^2	-0.2571 199.6 0.9928	-0.2579 199.7 0.9927	-0.2577 199.8 0.9923	-0.2578 199.9 0.9928	-0.2576 200.0 0.9925	
1.5/0-CAP-3	T102 Stats		T103 Stats		T104 Stats		1.5/0-CAP-3 Averages -0.1260 sccs 189.5 scc 0.9997
	P1 Stats	P2 Stats	P1 Stats	P2 Stats	P1 Stats	P2 Stats	
	SLOPE INTERCEPT R^2	-0.1261 189.6 0.9997	-0.1262 189.7 0.9997	-0.1262 189.5 0.9997	-0.1257 189.7 0.9997	-0.1258 189.4 0.9997	
1/0-CAP-3	T99 Stats		T100 Stats		T101 Stats		1/0-CAP-3 Averages -0.0843 sccs 132.7 scc 0.9993
	P1 Stats	P2 Stats	P1 Stats	P2 Stats	P1 Stats	P2 Stats	
	SLOPE INTERCEPT R^2	-0.0856 137.1 0.9991	-0.0840 130.7 0.9996	-0.0840 130.3 0.9995	-0.0833 130.7 0.9995	-0.0833 130.3 0.9994	

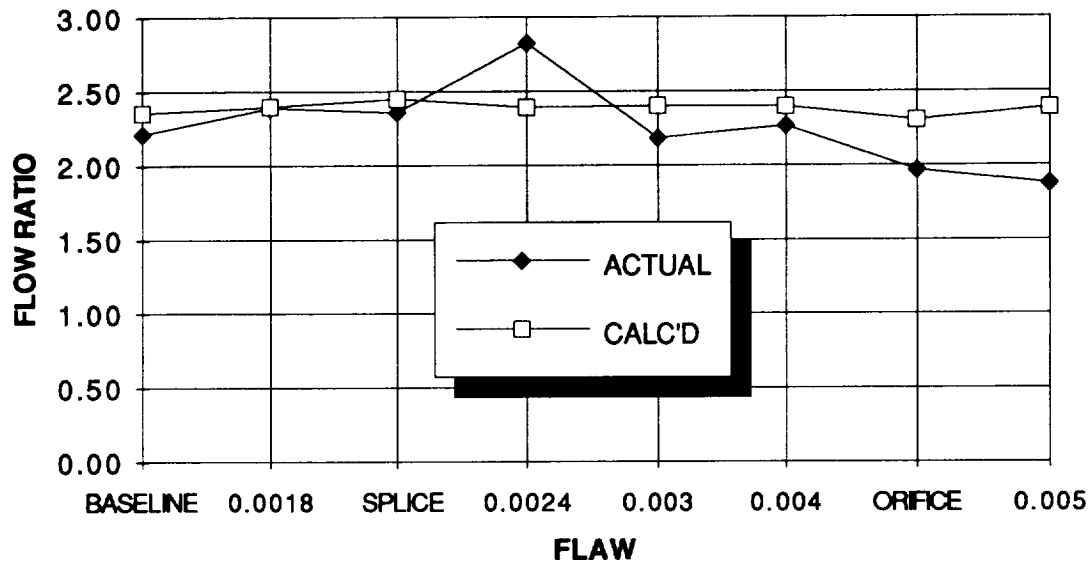
005-2 Average Data

2/1-005-2	T66 Stats		T67 Stats		T68 Stats		2/1-005-2 Averages -0.5824 sccs 260.1 scc 0.9987
	P1	P2	P1	P2	P1	P2	
	Stats -0.5892 260.5 0.9990	Stats -0.5841 259.9 0.9990	Stats -0.5820 260.2 0.9988	Stats -0.5762 259.6 0.9987	Stats -0.5836 260.4 0.9984	Stats -0.5792 259.8 0.9982	
1.5/1-005-2	T63 Stats		T64 Stats		T65 Stats		1.5/1-005-2 Averages -0.3102 sccs 200.5 scc 0.9981
	P1	P2	P1	P2	P1	P2	
	Stats -0.3075 199.9 0.9977	Stats -0.3080 199.8 0.9980	Stats -0.3239 202.0 0.9977	Stats -0.3228 201.8 0.9980	Stats -0.2995 199.9 0.9986	Stats -0.2998 199.8 0.9987	
1.5/0-005-2	T72 Stats		T73 Stats		T74 Stats		1.5/0-005-2 Averages -0.3890 sccs 200.5 scc 0.9993
	P1	P2	P1	P2	P1	P2	
	Stats -0.4087 200.2 0.9991	Stats -0.4098 200.2 0.9992	Stats -0.3790 200.6 0.9994	Stats -0.3788 200.4 0.9995	Stats -0.3785 200.6 0.9992	Stats -0.3791 200.9 0.9993	
1/0-005-2	T69 Stats		T70 Stats		T71 Stats		1/0-005-2 Averages -0.2159 sccs 126.3 scc 0.9991
	P1	P2	P1	P2	P1	P2	
	Stats -0.2170 126.4 0.9987	Stats -0.2157 126.4 0.9988	Stats -0.2162 126.2 0.9994	Stats -0.2166 126.3 0.9993	Stats -0.2157 126.4 0.9991	Stats -0.2143 126.4 0.9992	

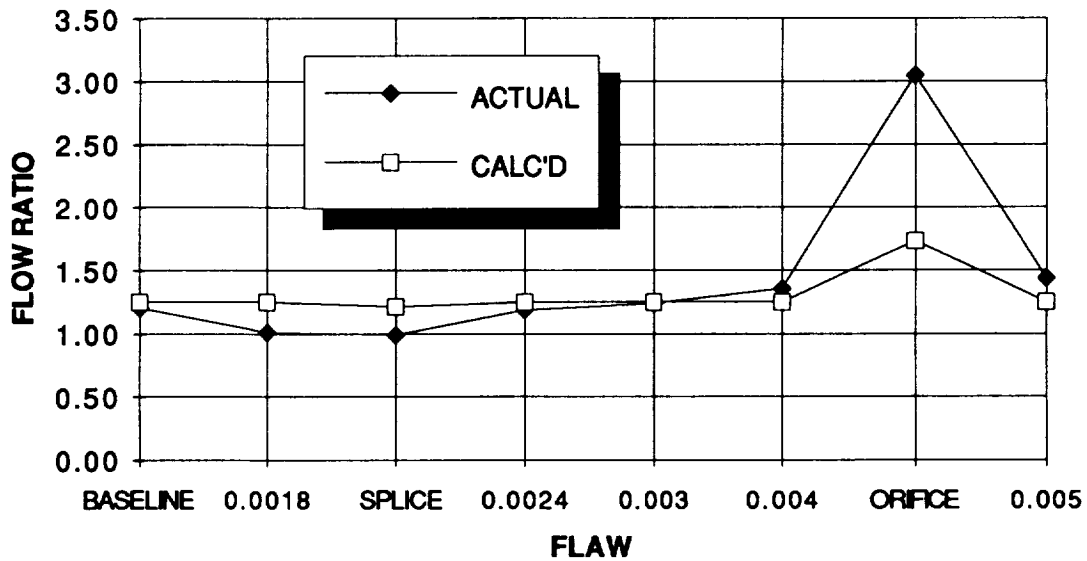
APPENDIX B
Flow Ratio Plots



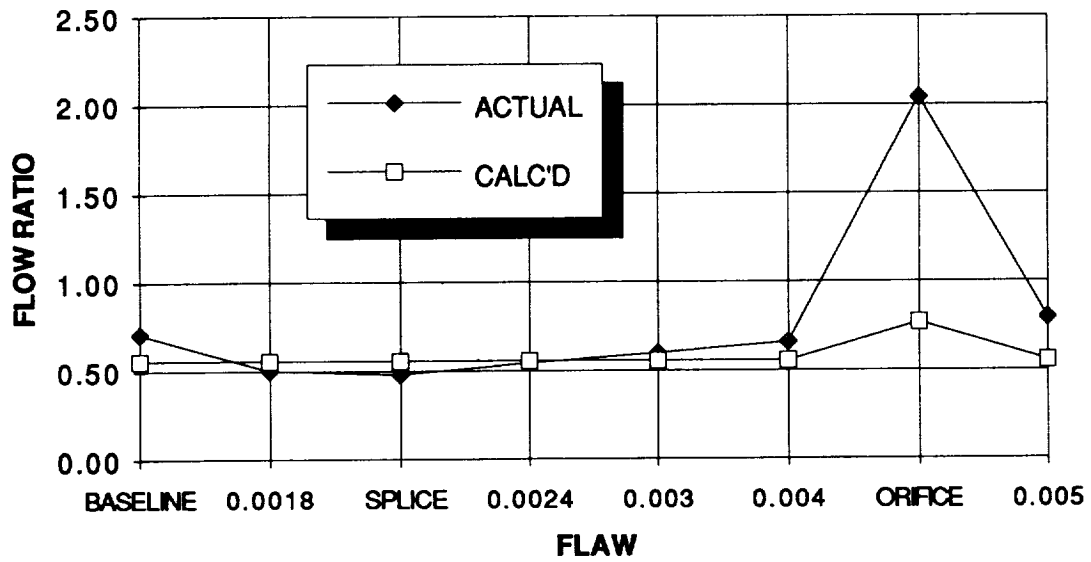
FLOW RATIO COMPARISON 2/1 TO 1.5/1



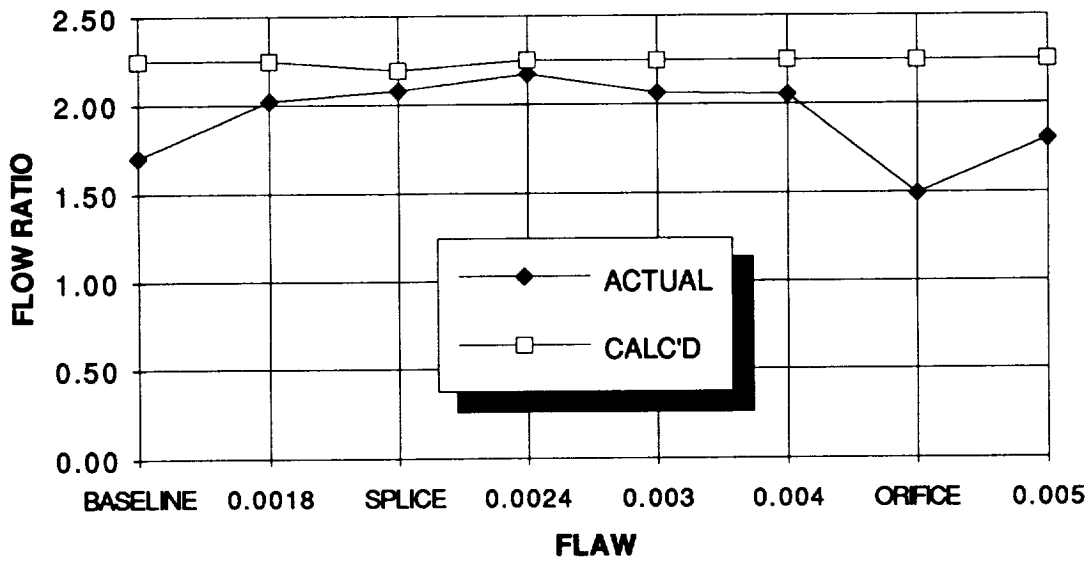
FLOW RATIO COMPARISON 1.5/1 TO 1/0



FLOW RATIO COMPARISON 1.5/1 TO 1.5/0



FLOW RATIO COMPARISON 1.5/0 TO 1/0



REFERENCE

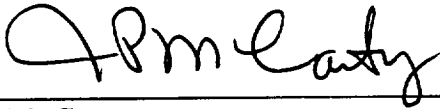
1. McMaster, R.C.: "Nondestructive Testing Handbook, Second Edition, Volume One—Leak Testing." American Society for Nondestructive Testing, American Society for Metals, 1982.


APPROVAL

SPACE STATION *FREEDOM* DELTA PRESSURE LEAKAGE RATE COMPARISON TEST DATA ANALYSIS REPORT

By E.B. Sorensen

The information in this report has been reviewed for technical content. Review of any information concerning Department of Defense or nuclear energy activities or programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.



 J.P. MCCARTY
Director, Propulsion Laboratory

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13. ABSTRACT (Maximum 200 words) This report provides results of a series of tests performed to identify the relationship between gas leakage rates across a seal at various internal to external pressure ratios. This report is intended to complement the results and provide insight into the analysis technique used to obtain the results presented in MSFC SSF/DEV/EL91-008, "Space Station <i>Freedom</i> (S.S. <i>Freedom</i>) Seal Flaw Study With Delta Pressure Leak Rate Comparison Test Report."				
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